



Department for
Business, Energy
& Industrial Strategy

UK Measurement Strategy

for the National Measurement System

December 2022



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Acknowledgements

The Government has developed this strategy in partnership with the laboratories which make up the National Measurement System, in consultation with the expert external advisers to the NMS and the wider measurement community of users. It takes into account a significant amount of econometric research and the outputs of foresighting and horizon scanning activities.

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Foreword

Measurement is essential for the smooth running of our everyday lives.

It enables scientific discovery by providing the basis for determining uncertainty.

It accelerates innovation by providing confidence in the performance of emerging technologies.

It allows trade to be equitable by ensuring compliance with standards and regulations.



The importance of measurement has never been more apparent than recently when, during the COVID-19 pandemic, the UK's National Measurement System (NMS) rapidly responded to quickly emerging challenges. While continuing to support the UK's critical national infrastructure by providing measurement and calibration services throughout the pandemic, the UK's measurement laboratories also:

- ensured safe PPE and supported new manufacturers;
- provided advice and guidance on the reliability of non-contact methods for fever screening;
- provided accurate and rapid analysis on communicable and respiratory disease data; and
- developed and provided SI-traceable reference materials to support vaccine development.

The agile response of our NMS shows the importance of maintaining and continuing to develop the UK's measurement infrastructure and expertise.

This strategy describes how the UK will capitalise on its world-leading National Measurement System in the 2020s. Extraordinary innovation can be realised when the right measurement practices are applied. Measurement can increase investment in R&D by giving confidence to investors, thereby de-risking the innovation journey. Measurement also helps to grow key high-tech sectors by enabling companies to assure quality, comply with regulations and trade internationally.

Through business support programmes the NMS provides UK industry access to the measurement infrastructure, knowledge and expertise that they need to enable development, take-up and adoption of new and emerging technologies and to speed up commercialisation. This is a vital service which supports the UK in being the best ecosystem in the world for starting and growing a business.

The research and development carried out by the NMS in metrology, the science of measurement, increases the efficiency and effectiveness of UK's R&D spending and supports the UK as a science superpower.

The digital revolution is bringing new challenges for metrology, and measurement is key to supporting the UK's current and future priorities and help it to prepare to address tomorrow's challenges. The NMS will continue to work in partnership with stakeholders and users of measurement to address emerging measurement needs in an agile and effective way.

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A strategy for the UK's National Measurement System

The National Measurement System (NMS) is an essential part of the UK's research and innovation infrastructure that is critical for science, innovation and trade.

This strategy describes how the UK will capitalise on its world-leading National Measurement System in the 2020s.

The National Measurement System will focus on three challenges where enhanced measurement capability and expertise will support the UK:

The health and wellbeing of a growing population

The National Measurement System will support the UK's position at the forefront of leading-edge healthcare, enabling people to live longer, healthier and safer lives.

Managing and reducing our environmental impact

The National Measurement System will provide the critical measurement infrastructure needed to help the UK improve energy efficiency, transition to clean energy sources and mitigate and adapt to the effects of climate change.

Increasing prosperity and supporting innovation

The National Measurement System will support new and existing innovative businesses, providing access to the measurement capability and expertise needed to translate new ideas into products.

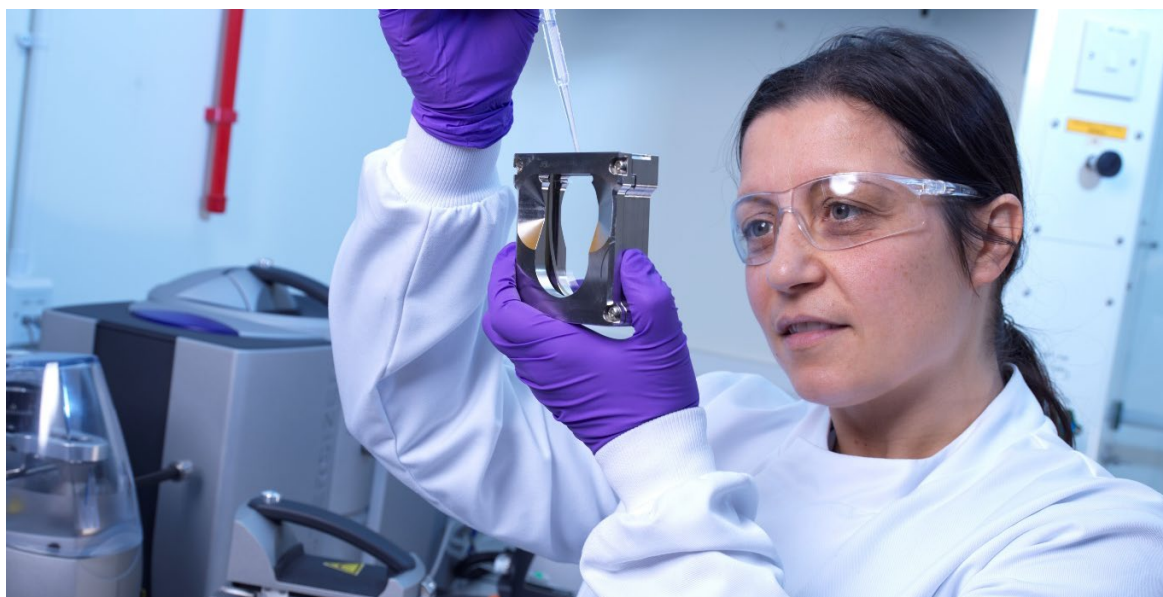


Image: Setting up a low volume cell for laser diffraction measurements.

The Government funds and supports the National Measurement System to provide the enduring and world-leading measurement infrastructure that the UK needs to be safer, healthier, greener and more prosperous.

To ensure the NMS continues to be fit for purpose, Government will fund and support the NMS to:

- **provide enduring and resilient measurement infrastructure** which ensures that measurements in the UK can always be made with integrity and consistency. For example, the NMS provides traceable, resilient and secure time and frequency distribution across the UK, essential for positioning and navigation, communications and power networks, financial trading, national security and defence;
- **develop and maintain agile and responsive measurement infrastructure technologies**, or infratechnologies, to support the creation and adoption of new technology. For example, the NMS Quantum Programme provides the facilities and expertise that the UK needs to be a leader in the creation and adoption of quantum technologies;
- **develop and maintain world-leading and internationally recognised measurement capability, standards and practices**, which underpin and advance scientific endeavour, technological innovation and trade. For example, in 2021 the NMS helped shape and influence more than 80 published national and international standards and regulations every year on behalf of the UK;
- **provide independent expert advice to the public and private sector** to inform decision-making and support standardisation, regulation, testing and enforcement. For example, the Government Chemist has addressed questions from Ministers on analytical limits of CBD (cannabidiol) and controlled cannabinoids in a range of food and cosmetics products to support novel food regulation and associated market surveillance testing;
- **provide a digitally-delivered measurement infrastructure** of services and standards to meet the needs of users, while also **providing confidence in the use of data** to support decision-making and investment, and accelerate innovation. For example, the NMS has developed a range of data-driven models which allow existing and new flow meter technologies to be calibrated in-situ, unlocking cost and capability benefits; and
- **ensure a healthy measurement research and development lifecycle within the NMS and to ensure measurement capability is widely accessible** by, for example, translating mature and well-established measurement capability and infrastructure to other public sector organisations or to the private sector when appropriate;

The NMS underpins key policies, regulations and operational requirements across government by enabling:

Assured food, air and water quality measurement for the Department for Environment, Food and Rural Affairs, Environment Agency and Food Standards Agency.

Safe and quality assured medical diagnosis and treatment in the NHS for the Department of Health and Social Care.

Assurance of breath alcohol measurement and of critical infrastructure monitoring for the Department for Transport.

Traceable measurements to support homeland and national security for the Home Office and Ministry of Defence.

National greenhouse gas inventories, observations of emissions in the UK and accelerating the development and uptake of low-carbon technology for the Department for Business, Energy & Industrial Strategy.

Measurements for the accurate taxation of, for example, oil and gas production for HM Treasury.

The health and wellbeing of a growing population

A healthy population with increased wellbeing represents significant opportunities for national prosperity and economic growth.

It is essential that we use measurement effectively to support confidence in the biological, medical and health sciences to tackle a wide range of health challenges and accelerate innovation in medical technology.

The UK population is growing and ageing, and is expected to reach 70 million by 2030, with average life expectancy projected to rise to 89 years for men and over 91 years for women [ONS - *Cohort life expectancy, 2018-based projection*]. It is essential that we support our growing population to age well [NHS *Long Term Plan*].

We also face societal, behavioural, environmental, geographic and socio-economic changes which will transform our health and wellbeing. These will include challenging areas such as outbreaks of new pathogens and infectious diseases, the emergence of life-threatening antimicrobial resistance, changes in disease prevalence due to changing climate and allergens from the ever-expanding variety and alternate sources of food.

Along with all these changes, expanding areas of medical needs are emerging in the form of non-communicable diseases such as cancer, neurodegenerative diseases, heart disease and genetic disorders:

- Half of the people born after 1960 will be diagnosed with some form of cancer and there are 360,000 new diagnoses each year in the UK [Cancer Research UK];
- In 2019 there were an estimated 850,000 people living with dementia in the UK. This is projected to reach 1.2 million by 2030 [Alzheimer's Society];
- In 2019 there were an estimated 4.7 million people living with diabetes in the UK. This is projected to rise to 5.5 million by 2030 [Diabetes UK]; and
- In 2019, an estimated 35 million adults in the UK (63% of the population) were overweight or obese. It is estimated that this could be as high as 55 million or 75% of the population by 2030 [Cancer Research UK].

Measurement will help us tackle the health and wellbeing challenges we face by ensuring confidence in the collection and use of data, strengthening consumer safety and public trust in science.

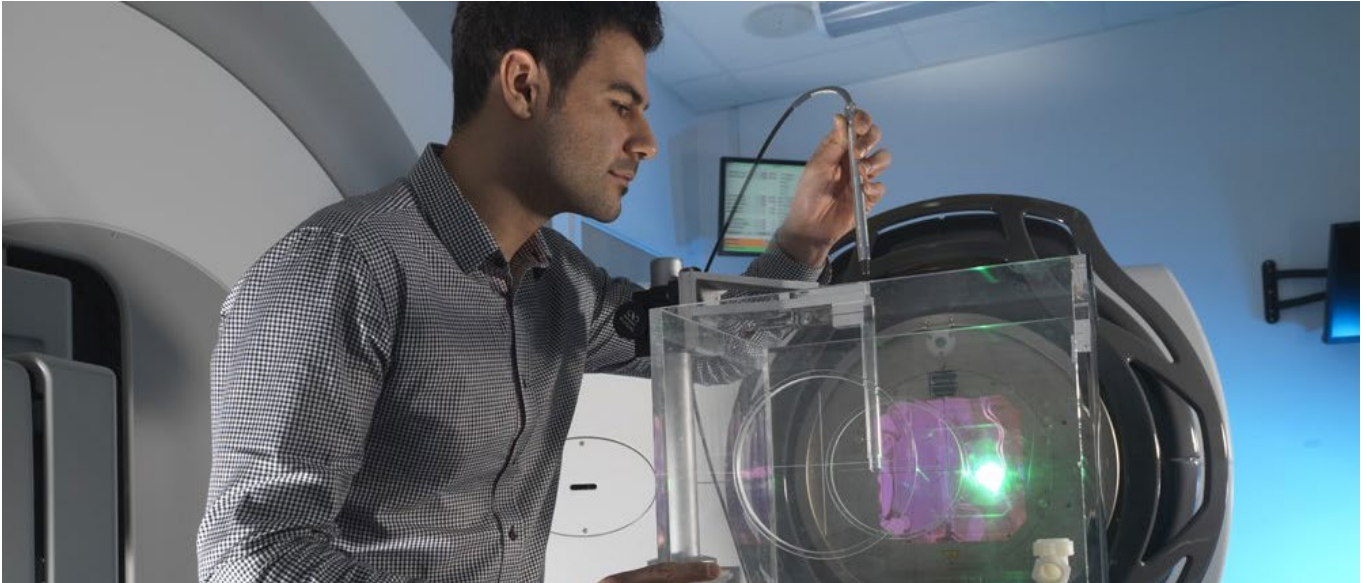


Image: calibrating a secondary standard ionisation chamber in a water phantom, using a clinical linac.

The National Measurement System will support the UK's position at the forefront of leading-edge healthcare, enabling people to live longer, healthier and safer lives.

Government's priorities for measurement research and development which supports the UK's position at the forefront of leading-edge healthcare are:

To continue to develop measurement expertise, capability and infrastructure to support and enable the wide range of existing and emerging treatment and diagnostic modalities, including clinical imaging and real-time, in vitro and in vivo diagnostics. This will help reduce the burden of chronic diseases on our growing and ageing population and increase readiness to diagnose, understand and treat current and future infectious diseases.

To focus on the metrology needed to improve our understanding of biological systems and processes and to enable patient stratification, through for example, biomonitoring, supporting early detection, diagnosis and optimised treatment of priority non-communicable diseases. This will help the UK continue to operate an equal and fair healthcare system, helping drive a transformation in healthcare towards personalised medicine, preventative medicine and a renewed focus on wellbeing.

To underpin the increasing use of high quality and trustworthy data needed in the health and life sciences, supported by the development of data quality and integrity frameworks which ensure common data standards and increased interoperability of data (medical and non-medical) and data security. This will help provide confidence in the data used for early diagnosis and precision medicine and will help address the challenge of overcoming the unprecedented measurement and data-handling requirements in metabolomics, proteomics, genomics and population phenotyping.

To support regulation and compliance in the areas of consumer protection and biosecurity, by ensuring that the best technology can be implemented at point of use. This will help address future emerging risks, ensure the safety of our food and water supplies, help tackle biosecurity threats to the population, industries and the environment and will support the development, manufacture and safe adoption of new therapeutic medicines and medical devices.

**Underpinning better patient care and driving innovation in the life sciences:
Accurate and reliable analysis of DNA**

The NMS DNA Measurement Laboratory, opened in 2019, gives the UK the capability to support research into synthetic biology, antibiotic resistance and personalised medicine. The measurement laboratory will also work to ensure that the public can have confidence in any clinical, environmental or industrial decisions that are made based on DNA measurements.



Image: DNA measurement laboratory

Managing and reducing our environmental impact

In order to manage and reduce our environmental impact it is essential that we understand the complexity of the interconnected systems which make up, and impact on, our environment.

Such understanding will allow us to provide the measurements and data needed to allow confidence in decision-making for the wide range of mitigation approaches available.

The UK's energy demand for living, manufacturing and transport are the principal source of environmental damage whether through greenhouse gas emissions, particulates, or other pollution. Although the UK's final demand for energy is projected to fall by approximately 17 million tonnes of oil equivalent by 2040 (9% less than the final demand for energy in 2018) this still represents 344 million tonnes of carbon dioxide equivalent in 2040 [BEIS energy and emissions projections 2019].

Climate change is a complex global problem and fulfilling societal needs while assuring a sustainable environment will require a whole systems approach. National action includes the UK Net-Zero Strategy, the UK Climate Change Act, Clean Growth Strategy, Clear Air Strategy and 25 Year Environment Plan and international action through collaborations such as the United Nations Framework Convention on Climate Change, the Intergovernmental Panel on Climate Change and the UN Sustainable Development goals. The UK's Nationally Determined Contribution to reduce greenhouse gas emissions under the Paris Climate Agreement is among the highest in the world and commits the UK to reduce emissions by at least 68% by 2030, compared to 1990 levels.

The UK's low-carbon economy is growing faster than any other part of the economy and could deliver between £60 billion and £170 billion of export sales of goods and services by 2030 [The Committee on Climate Change].

The natural environment will increasingly become a driver of our society and economy as we further understand its impact on human health, on climate change and as we understand and manage future supplies of our limited resources.

Measurement will help us tackle the environmental challenges we face by supporting our understanding of complex and interconnected systems, providing the data needed to make decisions with confidence.



Image: Flow measurement technology.

The National Measurement System will provide the critical measurement infrastructure needed to help the UK improve energy efficiency, transition to clean energy sources and mitigate and adapt to the effects of climate change.

Government's priorities for measurement research and development which supports the UK's transition to clean energy sources and helps mitigate and adapt to the changing climate are:

To focus on the measurement needed to assure carbon capture and storage for blue hydrogen, biofuels and difficult to transition applications such as baseload generation and foundation industries.

To support the acceleration of green innovation and enable the widescale uptake of zero-carbon energy for the transport sector by providing the metrology needed for efficient battery and fuel cell development and production as well as the manufacture of smart and advanced materials. This includes providing the measurements for full life-cycle analysis, ensuring materials processing and manufacturing complement the circular economy, enabling materials reprocessing, recycling and safe disposal.

To provide the measurement infrastructure needed to support the hydrogen economy as it develops to be the chemical alternative to hydrocarbon energy and providing the measurement capability to enable future taxation.

To provide confidence in the climate and emissions measurements by providing the metrology needed to assure remote sensing systems, long term monitoring programmes **and data needed for confident decision-making in climate response**, by supporting data assimilation, where climate observation are combined with modelled data.

To support the development and introduction of digital technologies and processes which will be essential for the realisation of a sustainable and net-zero carbon future economy. This will include the metrology needed to create and operate an intelligent, storage enabled, energy efficient electrical grid optimised for renewables.

Supporting the development of innovative green technologies

The NMS business support programme provide UK companies with access to specialist measurement science and engineering expertise to solve businesses measurement challenges, supporting innovation and helping companies to bring new products to market. For example:

Energy Technology Centre Ltd. accessed expertise in making measurements of the damage caused by water droplets during erosion testing for wind turbine blades. The developed system gives them greater insight into erosion mechanisms which will help them, and the wind industry, better understand optimal design, material selection and coatings for blades to increase lifetime and improve efficiency.

“The breadth of measurement and materials expertise [of the NMS] across different sectors proved invaluable. They were able to identify solutions applied to other materials challenges and bring them to bear on our problem, whilst also bringing knowledge of the nuances of wind turbine testing, enabling them to make the appropriate modifications to apply their technology to our specific challenge.” Dean Boyce - Senior Engineer - Energy Technology Centre Ltd.

The fuel cell industry collaborated with the NMS to develop an innovative reference electrode for hydrogen fuel cells to enable them to optimise their designs and to improve the lifetime of their products in this emerging market.

“This work has disrupted the conventional thinking and has paved the way toward the development of internationally-recognised accelerated stress tests [for electrolyzers]. It has not only helped speed up innovation to market within ITM Power but will benefit the industry as a whole.” Nick Van Dijk - ITM Power



Image: Hydrogen powered car at a fuelling station

Increasing prosperity and supporting innovation

As the UK's economy is increasingly driven by the need to achieve net zero carbon emissions by 2050 and the need to support the health, wellbeing and safety of a resilient society, we will require significant innovation and effort to ensure continued UK prosperity.

The challenges we face drive a need for constant productivity and competitiveness improvements to ensure continued economic growth, while also remaining safe and sustainable.

Manufacturing and other industrial enterprise make a significant contribution to maintaining and growing the nation's prosperity. In 2019, there were 3 million people employed in manufacturing, which contributed 17.4% of GDP and accounted for 45% of total exports, totalling £275 billion [ONS].

Innovation and productivity improvements are a key focus for UK research and development, as we work to realise improved performance and efficiency whilst maintaining safety. In 2017, 69% of business research and development undertaken in the UK was associated with manufacturing [ONS].

The challenges we face in health and wellbeing also drive exceptional effort in technological advances and innovation, global cooperation and increased access to new biotechnologies, medical devices, drugs and therapies. The UK bioeconomy in 2019 was worth £220 billion and supported 5.2 million jobs [Bioeconomy Strategy].

There is an urgent need for resilience in the industrial ecosystem. It must be able to rapidly adapt and respond to shocks, especially in our supply chains, while also supporting prosperity and productivity.

Measurement will help us tackle the economic challenges we face by accelerating the development and adoption of new, innovative technology which will revolutionise how we live and work.



Image: Flow measurement facility

The National Measurement System will continue to support new and existing innovative businesses, providing access to the measurement capability and expertise needed to translate new ideas into products.

Government's priorities for measurement research and development which supports new and existing innovative businesses are:

To provide confidence and assurance in adopting and exploiting new technologies, such as advanced autonomous systems, energy saving technologies, quantum technologies, nanotechnologies and artificial intelligence.

To accelerate the development of resilient communications and timing infrastructure, maintaining world-leading capability and applying it to accelerate innovation and safeguard our economy.

To enable the digital transformation of the economy and industry and support the UK's global relationships through digital measurement and calibration certification, which will help enable agile trade regulations, product information and safety standards.

To enable efficient and sustainable manufacturing through providing the measurement infrastructure to increase productivity while also enabling energy and resource conservation, for example, supporting increased agriculture yield and efficiency while reducing environmental impact.

To support the bioeconomy and the implementation of advanced bio-manufacturing processes and technologies, developing the measurement capability needed to support, for example, medicines manufacturing, and de-risk product development in the life sciences and health sector.

Developing secure future communications: Commercialisation of Quantum Key Distribution

Quantum Key Distribution is a secure communication method and one of the most commercially advanced quantum technologies. It enables a party sending encrypted information to produce a random secret key – transmitted in a quantum state – which can decrypt the message.

The Quantum Metrology Institute is supporting the commercialisation of Quantum Key Distribution by developing and validating methods for counting photons and measuring their quantum states.

Working with BT Research and Toshiba, amongst others, the aim is to create useable methods for sending encrypted messages, allowing customers to communicate with certainty that no one is listening in.

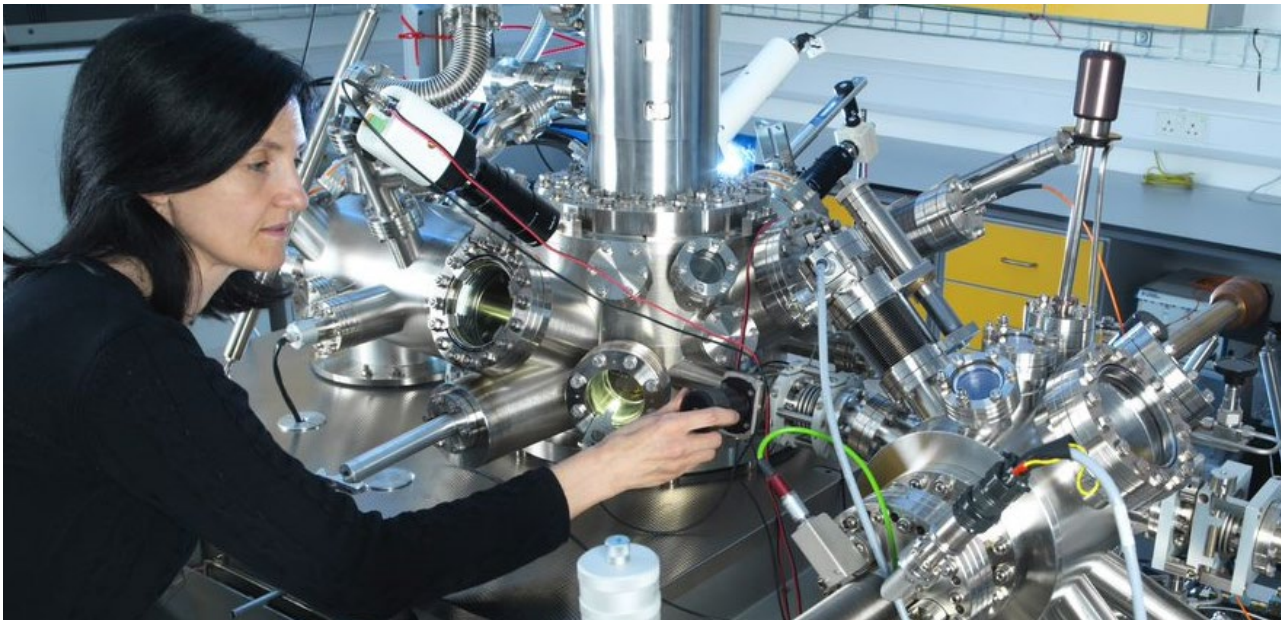


Image: Scanning tunnelling microscope

The National Measurement System

The Government maintains an enduring measurement capability and infrastructure because of the substantial impact it has on every aspect of UK life and economic prosperity:

- the NMS directly ensures the accuracy of the measurements required for the radiotherapy treatment of approximately 100,000 cancer patients every year;
- the NMS calibrates and assures high-resolution sensing technologies which make air pollution visible and measurable at an unprecedented scale and scope; and
- the NMS has a UK customer base of ~4,500 private sector businesses, who believe they would miss out on sales of at least £539m annually without NMS support.

The National Measurement System is the technical and organisational infrastructure which ensures a consistent and internationally recognised basis for measurement in the UK. It is an essential part of the UK's research and innovation infrastructure that is critical for science, innovation and trade:

- the NMS enables individuals and organisations in the UK to make measurements competently and accurately and to demonstrate the validity of such measurements by providing the coherent, formal framework which ensures that measurements can be made on a consistent basis throughout the UK; and
- the NMS coordinates the UK's measurement system with the measurement systems of other countries by providing the technical and organisational infrastructure which ensures a consistent and internationally recognised basis for measurement in the UK.

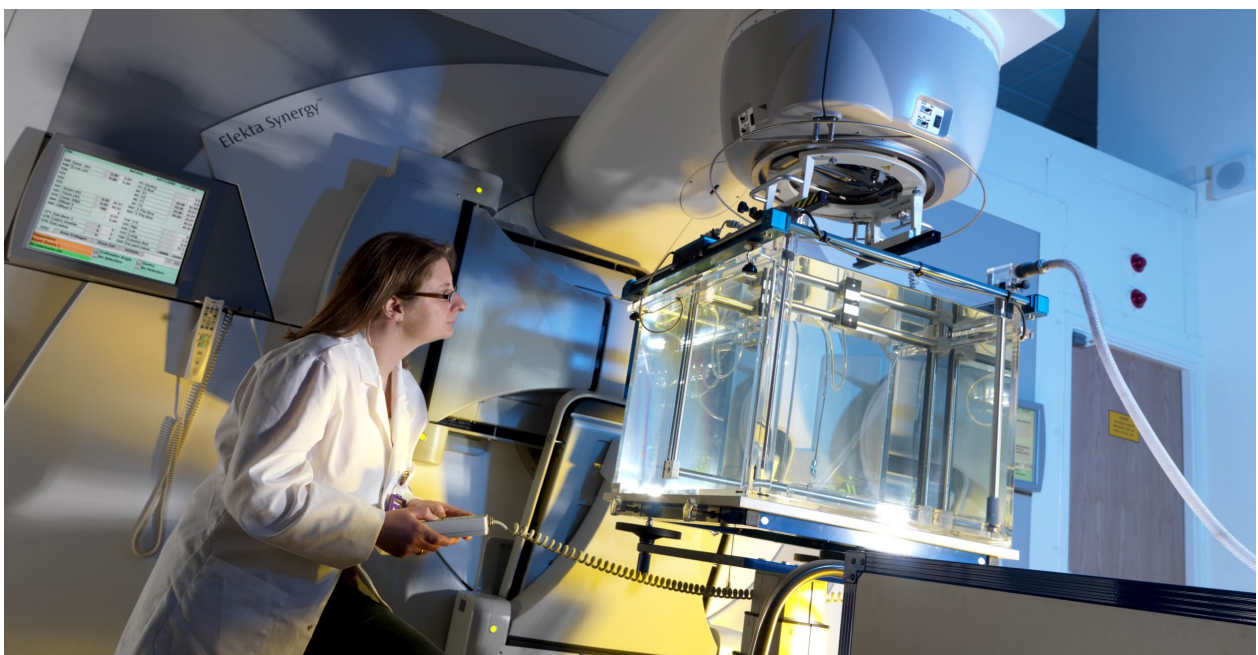


Image: Using a plotting tank to measure the beam characteristics of a clinical linac.

The NMS is developed, delivered and maintained by over 1,000 scientific and technical staff over 9 locations across the UK delivering the benefits of measurement to end-users in England, Scotland, Wales and Northern Ireland.

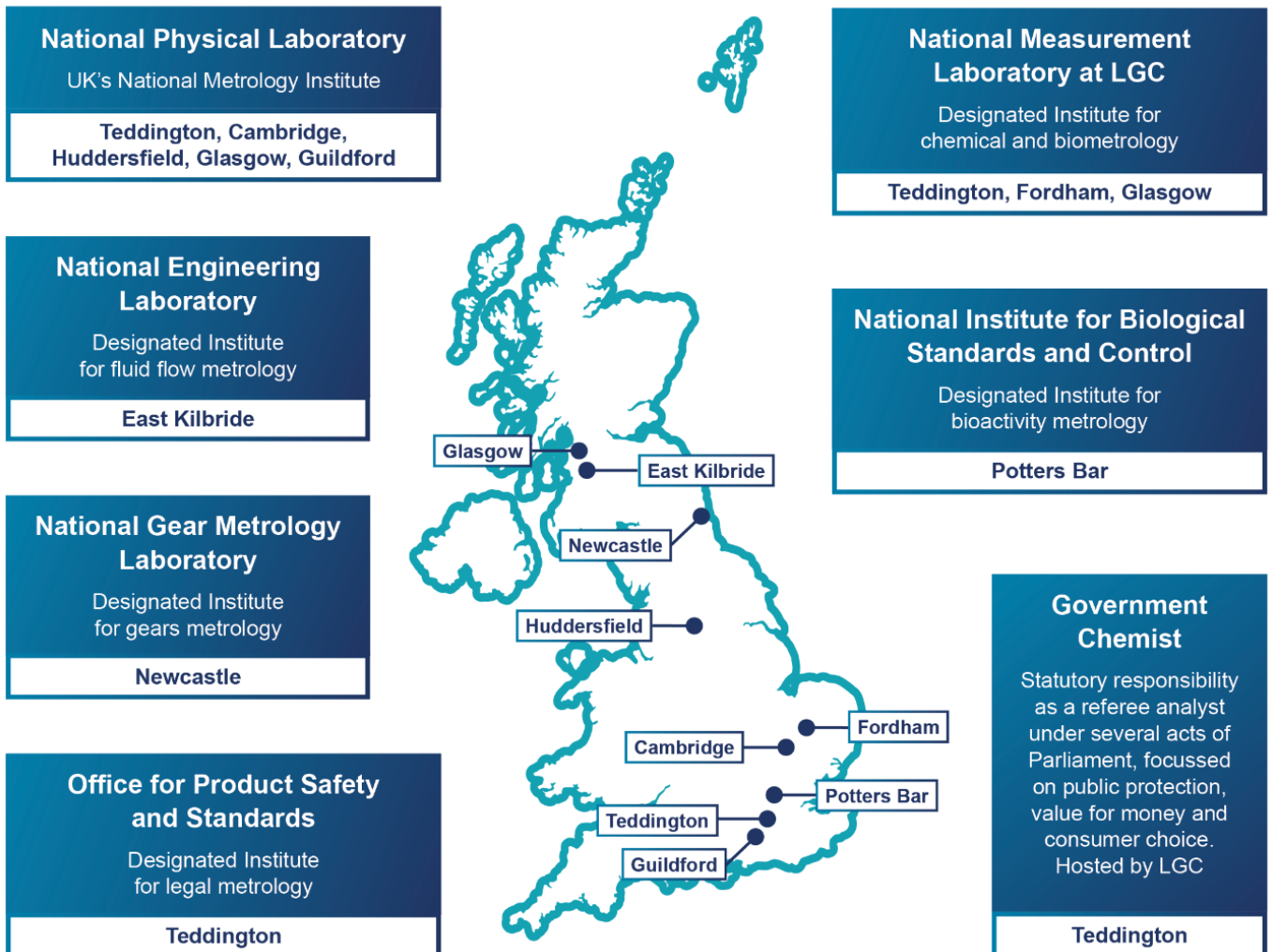


Diagram: The locations of the NMS laboratories across the UK.

Partnerships

Partnerships and collaborations between industry, researchers and government strengthen the broader technological ecosystem and play an important role in driving innovation activity throughout the UK.

The National Measurement System develops partnerships with the private sector to ensure that industry and large and small businesses have access to world-class measurement infrastructure, directly impacting how innovative they can be and maximising the potential of the UK's innovation ecosystem.

The National Measurement System also partners with academia, UKRI, the Research Councils and Innovate UK, other research and technology organisations and public sector research establishments, and local, regional and Devolved bodies to ensure the measurement needs of the UK are met.

The National Measurement System represents the UK in the international measurement community, cooperating with other measurement institutes around the world under a mutual recognition arrangement of national measurement standards and calibration and measurement certificates, and strengthening the UK's position as a science superpower.

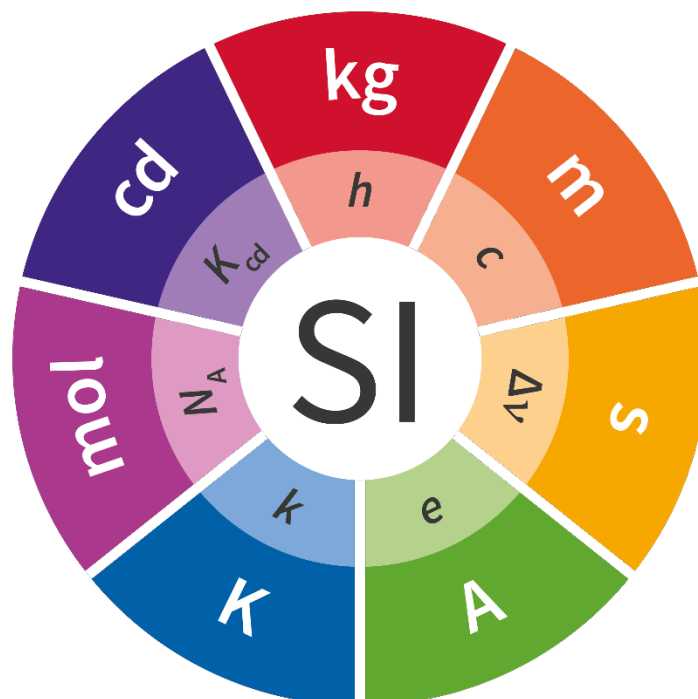


Image: Logo of the International System of Units, introduced in 2019 to mark the redefinition of the SI units.

Delivering this strategy

The National Measurement System focusses on four activities in order to ensure that the UK's measurement capability and expertise is fit to meet the challenges we face.

Leading within the global measurement community

The NMS plays a leadership role in the coordinated global metrology community of National Metrology Institutes, other measurement laboratories and standards and accreditation bodies, defining and performing fundamental and applied metrology research within many areas of expertise.

The NMS performs research with national and international partners, developing measurement technologies that will shape future industries, while at the same time maintaining world-class measurement infrastructure and operating with the agility necessary to address the UK's most immediate needs.

Continuous foresighting activities ensure that our established measurement infrastructure remains fit-for-purpose and is always prepared to help solve the most critical national and global challenges.

The NMS collaborates on cutting-edge research with over 1,000 business and academic partners throughout the UK, resulting in the publication of around 400 peer-reviewed papers every year.

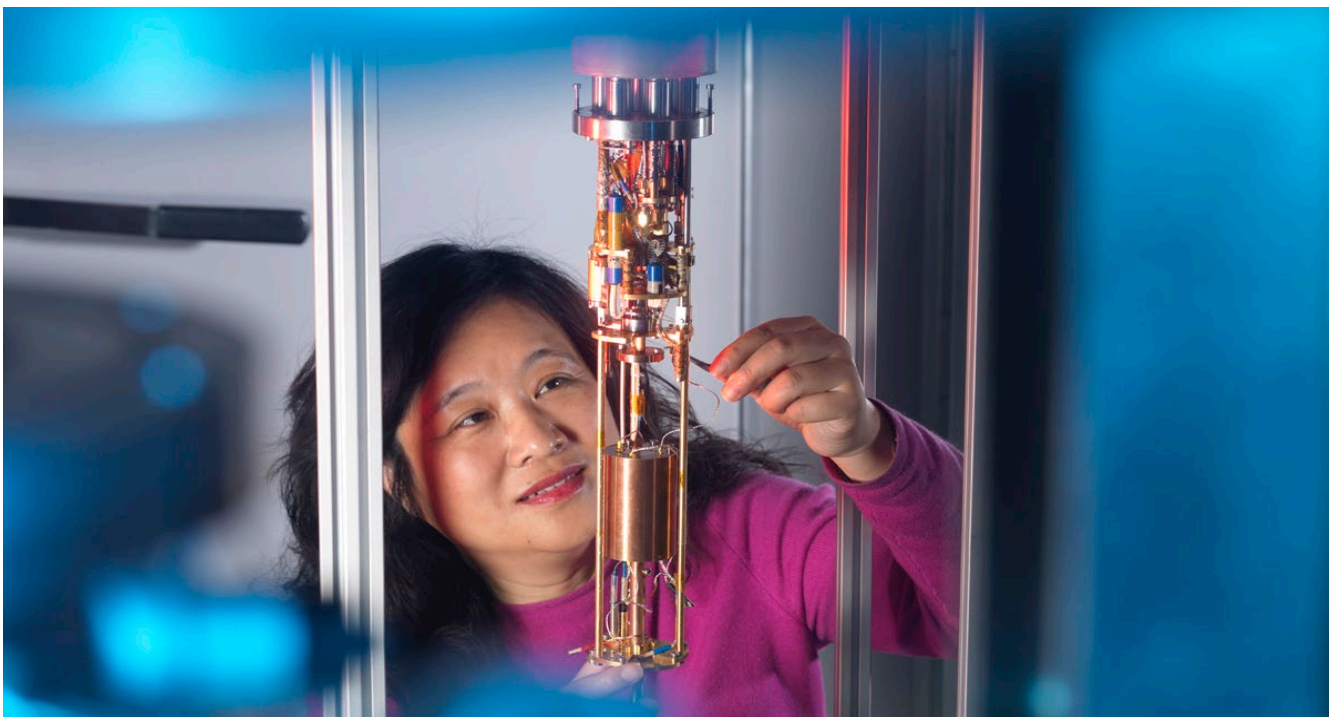


Image: tuning a microwave nano-scale superconducting quantum interference device (nanoSQUID)

Strengthening the UK's measurement skills

Measurement skills enable organisations and businesses to increase confidence in specifications and performance and boost productivity. Around 6% of all employment in the UK involves taking measurements.

The NMS develops the UK's technical measurement skills by collaborating with higher education establishments and training industry-ready measurement scientists and engineers, increasing the pool of measurement skills at all career stages.

The NMS provides apprenticeships, PhD training through multiple partnerships with universities, support for industry-led training networks and professional development and secondments for industry and academia.

The NMS conducts over 1,000 face-to-face training experiences across industry every year, with a further 2,500 people accessing measurement training via the web.



Image: A face-to-face training course on non-contact, large volume dimensional measurement

Playing a vital role in the UK's quality infrastructure

The NMS works closely with the British Standards Institution, the United Kingdom Accreditation Service and the Better Regulation Executive to provide a quality infrastructure for the UK, supporting the development of effective standards for trade, consumer protection and fair, traceable and consistent methodologies for enforcing regulation and championing an agile approach to standardisation.

The NMS maintains and develops the UK's national measurement standards, the highest point of reference for UK industry, which enables competitive and safe development, commercialisation and adoption of new technologies, products and processes.

NMS experts, in collaboration with the British Standards Institution, represent the UK in the collaborative field of international standardisation, influencing standards in areas of strategic advantage, and which promise transformational benefits for our economy and society.

The NMS enables compliance with relevant national legislation, such as the Weights and Measures Act 1985 and the Food Safety Act 1990, through its support of legal metrology and Government Chemist activities. The Government Chemist is a statutory role which underpins more than 15 legislative instruments and enables consumer protection. Measurements assured by the NMS also enable the UK to respond to several international treaties, for example in the areas of climate change, food, and nuclear energy.

The NMS provides over 400 measurement services and reference materials to over 2,000 UKAS accredited laboratories.

Over 74,000 UK businesses rely on measurements referenceable to NMS labs to trade and demonstrate compliance every year.

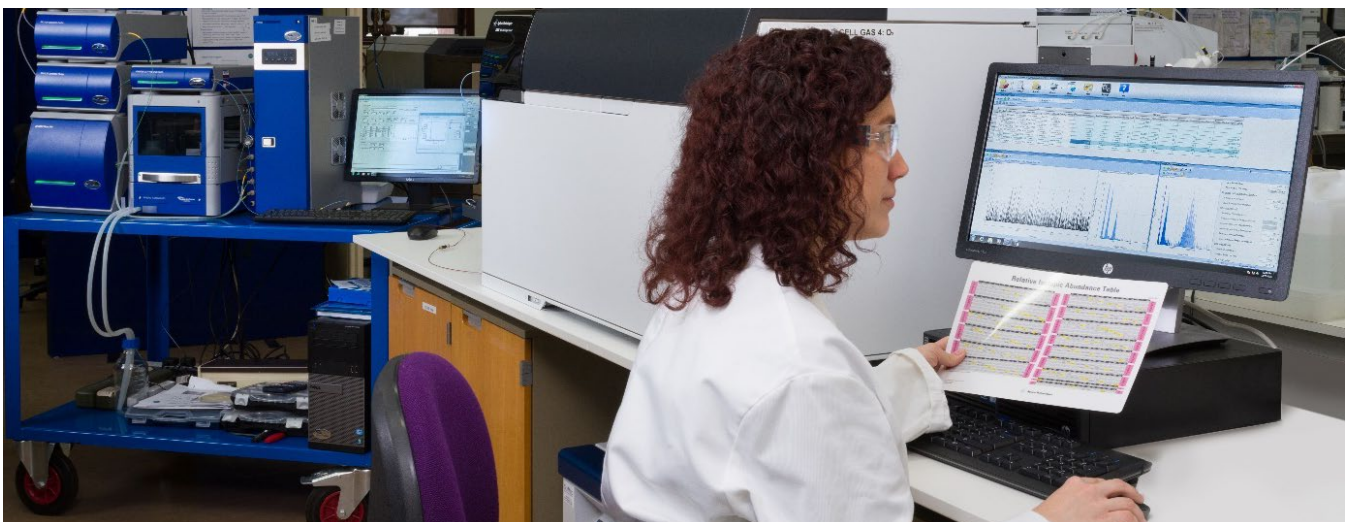


Image: Single particle inductively coupled plasma mass spectrometry nanoparticle analysis

Supporting and enabling innovation in the UK

Extraordinary innovation can be realised when the right measurement practices are applied.

Measurement plays an essential role in innovation by providing the advanced tools and knowledge required to design and incorporate new or better features into technologies. Access to cutting-edge measurement standards accelerates technology innovation and take-up across a range of industries, increases market competition, creates new markets and encourages investment.

The NMS supports and enables innovation in the UK by providing access to cutting-edge measurement expertise and facilities to help businesses research and solve measurement problems that can't be cracked using standard technologies and techniques.

Over 50% of the participants in Measurement for Recovery, a business support programme implemented by the NMS to aid companies during the COVID-19 pandemic, expect the contribution of NMS expertise in the development of their new product, service, or process to result in external financial investment.

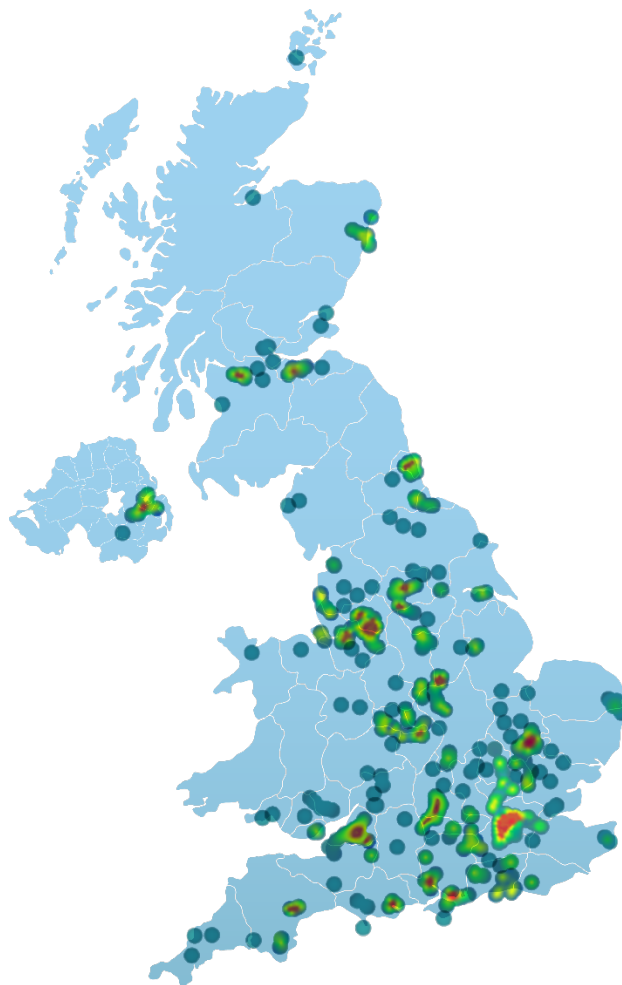


Diagram: A heatmap of the locations of 600 companies which completed collaborative R&D projects with NMS laboratories as part of the Analysis for Innovators and Measurement for Recovery programme in 2020 and 2021.

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